SILVICULTURAL OPTIONS FOR RECOVERING THE ENDANGERED SMOOTH CONEFLOWER: PRELIMINARY RESULTS[1]

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Abstract—Smooth coneflower (*Echinacea laevigata* (Boynton and Beadle) Blake) is a rhizomatous perennial with extant populations in Georgia, South Carolina, North Carolina, and Virginia (Murdock 1992). It was listed as an endangered species in November 1992, thus requiring management for recovery. This paper introduces a project to identify habitat characteristics of colonies found in Oconee County, South Carolina and provides a preliminary comparison of silvicultural treatments designed to promote regeneration. Results suggest that smooth coneflowers benefitted by treatments which removed forest floor litter. Removing the litter layer by raking was more effective for promoting regeneration than was prescribed burning or canopy removal.

INTRODUCTION

Smooth coneflower (*Echinacea laevigata* (Boynton and Beadle) Blake) was listed as an endangered species in November 1992. This plant is a rhizomatous perennial herb with extant populations in Georgia, South Carolina, North Carolina, and Virginia (Murdock 1992). Plants occur singly or in clumps and emerge from a basal rosette with one to eight or more leaves. Leaves are glabrous, yellow-green in color, and have parallel venation. The inflorescence appears in May through July and is purple to pink or white in color. The infructescence is brown and the awn of the pale is incurved. Seeds are prismatic achenes which mature in September or October. The only known mechanism of seed dispersal is gravity.

During 1990, 21 populations were known to exist in the Southeast. Fourteen of these populations were declining in number, one was increasing, and six were considered to be stable (Gaddy 1991). These populations had a total of approximately 6,000 plants but only 800 were flowering.

Smooth coneflower populations at one time were reported to number as high as 59, covering 24 counties in eight states (Murdock, 1992). Their decline is thought to have several causes: collection for horticultural and medicinal purposes, competition from woody plants, absence of natural disturbance, industrial and residential development, and right-of-way maintenance with herbicides.

Little is known about the habitat characteristics and regeneration requirements of smooth coneflower. Much of the current information about the plant in South Carolina is based on observations which are presented in a status report (Gaddy 1991) to the U.S. Fish and Wildlife Service. Gaddy's observations can be summarized as follows: the plant usually occurs on magnesium- and calcium-rich soils, it may require repeated disturbance and little competition, bare soil may be required for seeds to germinate, and seed viability and mechanisms of pollination are unknown.

Gaddy (1991) found smooth coneflowers most often on sites with abundant insolation, such as road cuts, open woods on exposed south-facing slopes, and young clearcuts where sunlight reached the forest floor He also found colonies in densely-vegetated sites with closed canopies. However, plants in these habitats appear to be declining in vigor and number. For these reasons, it is thought that the species may benefit from removing trees and other competing vegetation to increase light availability. Also, removing all or a portion of the forest floor may stimulate growth and reproduction.

The limited knowledge of the life history of this plant suggests that it is either a fire-associate (occurring under habitat conditions similar to burned areas) or a fire-dependent plant (requiring some mechanism that can be provided only by fire). Natural fires and grazing are a part of the land-use history over the range of smooth coneflower and many associated herbs require periodic disturbance (Murdock 1992). Before federal listing, fire was used to sustain two colonies on the Andrew Pickens Ranger District, Sumter National Forest. One colony, in a young clearcut, showed a large increase in numbers of plants and flowers after a winter burn. The second colony, which is in an open mature hardwood-pine stand, was also winter burned.

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The number of plants increased in this stand but few flowered. In this case, the fire may have stimulated growth without providing enough sunlight to promote flowering.

The objective of this paper is to introduce a new study of smooth coneflower habitat. The first phase of the study was to search for previously unmapped colonies of smooth coneflower in Oconee County, SC and to describe habitat conditions. The second phase was to examine flowering, fruiting, and recruitment after several silvicultural treatments designed to improve smooth coneflower habitat. This paper describes preliminary results of both phases.

METHODS

The first phase of this study was to search for previously unmapped smooth coneflower colonies in Oconee County, SC and to describe habitat conditions where they occurred. The search was concentrated, at first, on ridgetops and south-facing slopes where the plant was thought to be most common. However, the search was expanded to include a wide range of aspects and slope positions. Searches were conducted during May and June of 1993, when plants were flowering. Additional searches continue on an irregular basis. The following data were collected at each colony site: slope position, slope gradient, aspect, composition of competing plants, terrain shape index (McNab 1989), distance from the nearest canopy opening, number of coneflower rosettes and flowers, and the size of the area occupied by smooth coneflowers. Although not a component of this paper, these data will be used to define common habitat attributes and to produce GIS maps of sites with those attributes for additional searches.

The second phase of the study began with selection of colonies for the study of habitat manipulation. Twenty-one colonies were chosen from among those found during the searches described above. Each chosen colony was on Federal- or state-owned land, under a forest canopy, and considered unlikely to persist without some form of disturbance. Seven treatments were assigned to these colonies in a completely random design and replicated three times. Treatments included:

1. removal of understory trees,
2. removal of understory trees and winter prescribed burning,
3. removal of understory trees, raking the forest floor, and clipping competing vegetation,
4. removal of all trees,
5. removal of all trees and winter prescribed burning,
6. removal of all trees, raking the forest floor, and clipping competing vegetation, and
7. no treatment (control).

Two levels of tree removal will allow a comparison of smooth coneflower response to differing levels of light. In southern Appalachian hardwood stands, most shading comes from understory trees. Removal of the understory may provide adequate light while allowing overstory trees to remain for aesthetic, wildlife, or timber objectives. Removal of overstory trees eliminates all overhead shading but may increase basal sprouting of trees that will compete with coneflowers. Both felling treatments were conducted in January and February, 1994. Understory trees (2 feet tall through suppressed and intermediate crown classes) were cut from all plots (except controls). All other trees were cut from half of those plots. Directional felling was conducted by research crews to ensure coneflower protection.

After felling, each plot was randomly assigned one of three treatments designed to disturb the forest floor: prescribed burning, raking, or no disturbance. Six plots were burned in February 1994 using the strip-headfire technique. A winter burn was selected for this study because of the success of previous fires conducted by the Andrew Pickens Ranger District. Annual summer burning is the most successful regime for eliminating hardwood competition (Waldrop and others 1992); however, summer burns might interfere with seedling establishment because seed production occurs throughout summer. All burns were cool (flames less than 3 feet tall) and consumed only a portion of the leaf litter layer.

The raked plots were cleared of all leaf litter in February 1994 using leaf blowers. Efforts were made to remove the entire L layer, leaving the F and H layers intact. Competing vegetation within 3 feet of each plant was clipped during the first week of April, May, and June, 1994. This raking and clipping treatment was designed as a comparison to prescribed burning to determine if smooth coneflowers require fire or simply the conditions created by fire. Branches and tops created by tree felling were removed from raked sites to simulate burned conditions.

Measurements of coneflowers were conducted in September 1993, before treatment, and again in September 1994. Data included: numbers of coneflower clumps and rosettes, number of leaves per rosette, length and width of the largest leaf per rosette, length of the inflorescence stalk (peduncle), number of leaves per peduncle, and percent cover by trees, vines, shrubs, and herbs. Soil samples were collected from each plot for nutrient analysis. Of these data, only the number of rosettes and flowering plants are presented here.

RESULTS AND DISCUSSION

Status Survey

The survey of sites, conducted during the spring of 1993, showed a substantial increase in the number of smooth coneflower plants, in Oconee County, SC, over

that reported in the 1990 status report (Gaddy 1991). Our survey found 3,253 plants as compared to only 382 plants in 1990 (Table 1). Flowering plants numbered 506 in 1993, but only 123 in 1990. These increases are thought to be due to survey technique rather than true increases in plant numbers. Our survey was conducted over a two-month period with a six- to eight-person crew. The previous survey was limited to one person and a shorter time period.

Table 1--Status of smooth coneflowers in Oconee County, SC in 1990 (Gaddy 1991) and 1993

	1990	1993
Number of colonies	6	5
Number of plants	382	3,253
Number of flowering plants	123	506

Colony sites were found most often in mixed-species stands. Forty-eight percent of the colonies were in the hardwood-pine type and 34 percent were in the pine-hardwood type (Table 2). An additional 17 percent of the colonies were in pure hardwood stands. Only one colony was in a pure pine stand; this colony was on the edge of a young planted loblolly pine (*Pinus taeda* L.) stand.

Table 2--Selected characteristics of smooth coneflower sites found in Oconee County, SC in 1993

Characteristic	Percent of all colonies
Forest cover type	
Hardwood	17
Hardwood-pine	48
Pine-hardwood	34
Pine	1
Aspect	
Southeast	6
South	39
Southwest	42
West	13
Slope position	
Ridgetop (75-100 percent)	25
50-75 percent	45
25-50 percent	24
Bottom (0-25 percent)	6

The observation that smooth coneflowers require high levels of sunlight (Gaddy 19991) appears to be supported by the limited range of aspects on which the plant occurred. The majority of the colonies had a southwestern (42 percent) or southern (39 percent) exposure (Table 2). A few sites had western (13 percent) or southeastern (6 percent) exposures. No plants were found on sites with eastern or northern exposures.

Smooth coneflower colonies were not limited to ridgetops and drier sites. Only 25 percent of the colonies were found on ridgetops, while 69 percent were at midslope (Table 2). This result may suggest that smooth coneflowers prefer fertile, well-drained soils or they do not compete well on harsh, exposed sites. Six percent of smooth coneflower colonies were found on slope bottoms, but most of these sites included the heavily disturbed bottom areas of roadcuts.

Response to Habitat Manipulation Treatments

The total number of smooth coneflower plants in study plots after one growing season was similar to the number counted prior to treatment (Table 3). Apparently, the plant is not adversely affected by disturbance. Increases in plant numbers were observed in treatment plots with the two heaviest levels of disturbance, i.e., understory removal + raking and total tree removal + raking. Complete canopy removal did not provide additional benefits over removal of the understory alone. Moreover, prescribed burning did not affect plant numbers. These treatments may show increased plant numbers in 1995. Smooth coneflower seeds do not drop until late autumn or winter, therefore, any response of seedling establishment to treatments cannot be observed until 1995.

Table 3--Total number of plants by treatment and year

Treatment	1993	1994
Control	124	126
Remove understory	91	89
Remove understory and burn	65	74
Remove understory and rake	121	167
Remove all trees	230	191
Remove all trees and burn	77	78
Remove all trees and rake	184	238

Reductions of plant numbers were observed only in plots where all trees were removed and the forest floor had no other disturbance (Table 3). This response may be the result of shading or physical barriers from the large amounts of woody debris created by this treatment. In other treatment plots, small branches were either consumed by fires or removed by hand.

The total number of flowering plants remained small in all study plots except where all trees were cut and the forest floor was raked (Table 4). In these plots, only four plants flowered in 1993 prior to treatment but 42 plants flowered in 1994. Greater responses may be provided by removing more of the forest floor than did the treatments used in this study.

CONCLUSIONS

Study results are preliminary and conclusions stated above may change after data analysis is complete. Ou survey found more smooth coneflower colonies and

Table 4--Total number of flowering plants by treatment and year

Treatment	1993	1994
Control	4	5
Remove understory	1	5
Remove understory and burn	5	3
Remove understory and rake	3	10
Remove all trees	3	5
Remove all trees and burn	6	11
Remove all trees and rake	4	42

plants in Oconee County, SC, than a previous survey. However, these increases probably result from intensive searching techniques and are not true population increases. Plants were found more frequently on middle to upper slope positions than on the ridgetops where we expected to find them. Smooth coneflowers were not adversely affected by disturbance and appeared to have benefitted by removing the litter layer by raking. The differing levels of light, provided by canopy removal treatments, did not affect plant numbers. Flowering responses were minimal the first year after treatment, but the greatest increases occurred where the litter layer was removed. This study will be followed for several years to allow data collection on longer-term responses to treatments.

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Eighty-eight papers and two abstracts address a range of issues affecting southern forests. Papers are grouped in several categories including a general session, ecosystem management, vegetation management, pest management, natural disturbance, biometrics, economics, site productivity, site impacts, ecophysiology, genetics, regeneration, silvicultural systems, stand development, and intermediate management. Fourteen papers, on varying topics, are presented from a poster session.